Design and Implementation of 0.1KVA Dual Output Dc Uninterrupted Power Supply (Ups)

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ABSTRACT
Uninterrupted power supply (UPS) provides short-term power back-up to sensitive electronic and electrical equipment, where unexpected power outages could lead to undesirable outcome. The UPS usually serves as a bridge between connected equipment, the utility mains power and other long term back-up power systems like generators. A dual output DC uninterrupted power supply (UPS) provides supply and backup to two different dc loads in an event of power outage. This is quite different from the conventional UPS which provides AC outputs. Using the required circuit components with the right method of analysis, this device is able to produce 5VDC and 19VDC outputs respectively. From the result, it is established that it is possible to provide supply and backup to dc loads without using an adaptor. This is basically a cost effective approach to maintain power supply to devices connected to the mains, thereby avoiding any interruptions due to power outage. This device finds application in powering mobile phones and laptops.

Keywords: *Dual output, Uninterrupted Power Supply, DC load.*

I. INTRODUCTION

An uninterruptible power supply (UPS) or battery backup is an electrical device that provides emergency power to a load when there is power outage from the mains supply. A UPS differs from an emergency power system or standby generator in that, it will provide near-instantaneous protection from input power interruptions, by supplying energy stored in batteries, or super capacitors to the load. The battery runtime of most uninterrupted power sources is relatively short (only a few minutes), but sufficient to start a standby power source or properly shut down the protected equipment.

A UPS protect hardware such as computers, telecommunication equipment and other electrical devices, where unexpected power disruption could cause injuries, serious business disruption, damage or data loss. UPS units range in size from units designed to protect a single computer to large units powering entire data centers or buildings. The primary role of any UPS is to provide short-term power when the input power source fails. However, most UPS units are also capable of correcting common utility problems which includes: Voltage spike or sustained overvoltage, sustained reduction in input voltage (usually injected into the line by nearby equipment), Instability of the mains frequency and Harmonic distortion (resulting from non-sinusoidal waveform) on the line. UPS units are divided into categories based on their ability to handle the aforementioned problems and other related power issues. The three general categories of modern UPS systems are On-line, line-interactive and standby UPS. An On-line UPS uses a "double conversion" method by accepting AC input, rectifying it into the DC form, in order to feed the rechargeable battery (or battery strings). The output of the battery is converted back to

120 V/230 V AC for powering the protected equipment. A line-interactive UPS maintains the inverter in line and redirects the battery's DC current path from the normal charging mode to supply current when power is lost. In a standby ("off-line") system, the load is powered directly by the input power and the backup power circuitry is only called up when the utility power fails. Most UPS below 1 KVA, are of the line-interactive or standby variety, which is usually less expensive. For large power units, Dynamic Uninterruptible Power Supplies (DUPS) are sometimes used. DUPS are sometimes integrated with a diesel generator that is turned on after a brief delay, forming a diesel rotary uninterruptible power supply (DRUPS).

II. PROBLEM STATEMENT

In Nigeria (as a case study), power outages have been a major problem. This has persisted despite the effort of the government to provide constant power supply. However, it`s population depends to a great extent on utility power supply for business, entertainment, recreation as well as domestic application. The evolution of cell phones, laptop and smart TVs have also led to more dependence on utility power supply which is not always readily available. The industrial and commercial UPS such as line-interactive and On-line UPS; actually provide backup in the event of power outages. However, these UPS cannot provide direct supply and backup to dc voltage loads, without connecting external adapters which is required to convert the 230V AC output to the desired dc voltage. Hence the need to design and implement a dc uninterrupted power supply (UPS) that can power dc load without an adapter

III. REVIEW OF RELATED WORKS

Power surge is a sudden increase in electrical voltage, caused by nearby lightning strikes. Though, every device has a surge suppressor. The latter simply redirects any unwanted voltage surges that may damage a device. This led to the development of filters and conditioners. A line conditioner filters noise out of AC lines. This noise degrades the power supply and causes it to fail prematurely (Eric Steven Raymond, 2007). They also protect short voltage dropouts and enhance surge suppression. Conditioners may consist of a transformer that attempts to smooth out fluctuation in input voltage, to provide near uniform output. But these conditioners cannot provide backups in the event of an outage. Thus, the idea of an uninterrupted power supply (UPS) was conceived.

Uninterruptible power supply was invented by Simonelli et al (2009), and legally assigned to American Power Conversion. A power supply system has a power input, power output, battery module, to provide battery power, power module, controller (coupled to at least one power module, to monitor and control the output power from the power module), and a redundant controller, to provide redundant monitoring and controlling of the output power from the power module.

Joseph Shu (2003) invented the built in UPS hub, which is one of the popular UPS devices. This UPS consists of a control circuit, a USB hub circuit, an electric transformer and a rechargeable battery. The control circuit of the ups has a USB power conversion circuit to transform the 12V of the UPS to 5V for the USB hub circuit. The UPS is connected to a computer through a USB cable and utilizes power control software on the computer to monitor power supply of the UPS.
This was shortly followed by mode-dependent grounding UPS which was invented by George Arthur Navarro (2016). This type of UPS system includes: an inverter circuit having an input

coupled to a DC link, an output configured to be coupled to a load and a gang switch (e.g., a contactor) which couples and decouples the DC link to and from a DC power source.
Furthermore, the power supply systems and methods that supports load balancing were invented by Robert William Johnson, Jr. This UPS system includes a multiphase AC output coupled to a load, an inverter and a control circuit. This UPS compensates for phase imbalance of the load coupled to the AC output. This ensures power is being delivered to the load from an AC power source, independent of the inverter (US PATENT, 2013).

In another development, the DC UPS backup voltage with auto-ranging Capability *was invented by Steven* M.G. and Trung Le (2010). This device provided DC power supply having auto-ranging battery backup voltage capability. A peculiar property of this device is that it contains backup circuit made up of first and second strings of batteries to maintain current flow in a direction. The switch operates when the first and second strings of batteries are in series when closed, and parallel when open. This demonstrated the fact that a DC uninterrupted power supply having direct contact with dc load is realistic. This idea inspired the objective of this work, which is, to consider a dual DC UPS device which will not only serve for dual purpose, but will also function without an adapter.

IV. MATERIALS/METHODOS

In developing this project, sub-units were created. All materials and component used were purchased directly from the dealers. However, the casing was fabricated locally using metallic materials. Proteus software was used to understand the functions and characteristics of the circuit component, from which the circuit of a dual output dc UPS was developed and tested. Components were selected using data sheet, of which the developed circuit was built on a Vero board, and packaged with a casing.

FLOW CHART OF DESIGN METHODOLOGY

The flow chart in figure 1 shows the process involved in the design and implementation of dual DC uninterrupted power supply (UPS).

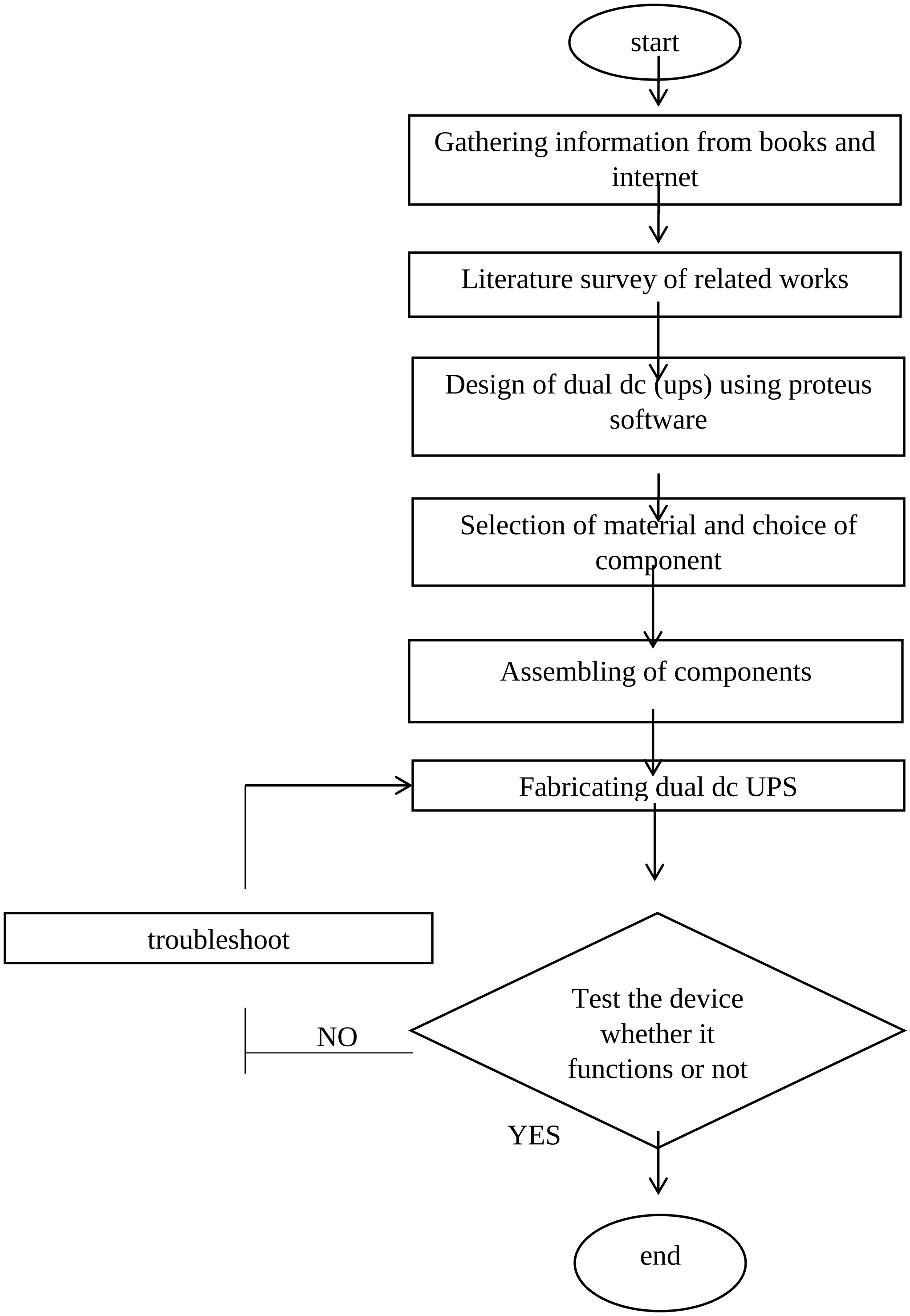

Figure 1. Flow chart of Design Methodology

BLOCK DIAGRAM

The block diagram of the system sub-units is represented in figure 2. The arrow lines indicate the direction of operation.

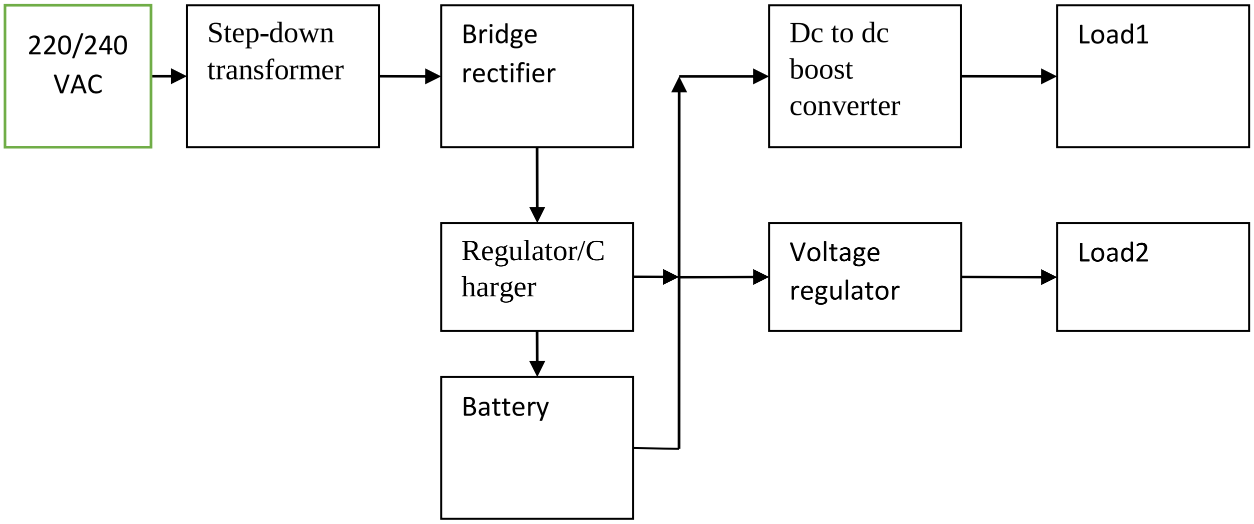

Figure 2 Block diagram of Dual DC Uninterrupted Power Supply (UPS)

COMPONENTS

A dual DC UPS, consist of a step-down transformer, charger, battery, voltage regulator, boost converter, inductor, switch, fuses, diodes, resistors and capacitors. The value of various components was chosen based on design requirement. Proteus and Multisim software were used in performing software testing of the components. Some component values were calculated using existing model, while others were extracted directly from component Data sheet based on design requirement. Multisim was used to develop the complete circuit diagram.

INDUCTOR SELECTION

Estimation for the ripple current of an inductor with unknown value for a boost converter is 20% to 40% of the output current.

$$\Delta Il = (0.2\ to\ 0.4) * Ioutmax * \frac{Vout}{Vin}$$

Vin = typical input voltage
Vout = desired output voltage
ΔIL = estimated inductor ripple current
Iout(max) = maximum output current necessary in the application

$$\Delta Il = (0.2\ ) * 5 * \frac{19}{10} = 1.9A$$

$$L = Vin(Vout - Vin) \div \Delta Il * Fs * Vout$$

Vin= typical input voltage
Vout = desired output voltage
fs = minimum switching frequency of the converter
ΔIL = estimated inductor ripple current,

$$L = 10(19 - 10) \div 1.9 * 52000 * 19 = 46.8uH$$

Therefore, 47µH was chosen as the value of the inductor for the design.

$$Load1\ Output\ Power = Iout * Vout = 5 * 19 = 95W$$

$$Load2\ Output\ Power = Iout * Vout = 1 * 5 = 5W$$

$$Total\ Output\ Power = load1 + load2 = 19 + 5 = 100W$$

Bridge Rectifier Ripple Voltage

$$Vripple = \frac{Iload}{fc}, volts$$

Where: load1 is the DC load current in amps

f is the frequency of the ripple or twice the input frequency in Hertz

C is the capacitance in Farads.

A full wave bridge rectifier was used. This choice is because; the rectifier has a smaller AC ripple value for a given load and a smaller smoothing capacitor than an equivalent half-wave rectifier. Therefore, the fundamental frequency of the ripple voltage is twice that of the AC supply frequency (100Hz), while the half-wave rectifier is exactly equal to the supply frequency (50Hz).

The AC/DC conversion process involves inverting the negative cycles of the AC input. This process required the use of a full wave rectifier diode bridge. The required specification for the bridge rectifier depends on the input voltage and current. The rectifier has the ability to handle the peak voltage of 20V and current of 2A.

The 2N358 rectifier was used for this project.

Input voltage =24V Ac

Output dc voltage =0.9V

Output ac voltage = **Vs** = 24V

0.9 × 24 = 21.6Vrms

$$Ripple\ factor, RF = \{\left(\frac{Vrm24s}{Vdc}\right)2 - 1\}\text{^}0.5$$

$$Rf = \left\{\left(\frac{24}{21.6}\right)^2 - 1\right\}^{0.5} = 0.484$$

$$Efficiency = \frac{Pdc}{Prms} = \frac{18}{20} * 100\% = 90\%$$

CAPACITANCE; the rating of the AC output from the transformer is 24Vrms at 50Hz. The regulator draws a maximum current of 2A to charge the battery. The required minimum capacitance value is determined using the formula:

$$C = \frac{Iout}{2} * f * RF * Vin$$

I out = Imax = 1.5A. This is based on the fact that the current that a lead acid battery dissipates when charged with is 2A. Therefore, for a constant voltage charger, 1.5A can be considered the maximum current that can be delivered to the battery.

$$C = \frac{1.5}{2} * 50 * 0.484 * 24 = 1291.32uF$$

Therefore, 2200uF, 50v capacitor was used.

Table 1: Parameters of the step-up (boost) converter

Necessary Parameter	Value
Input Voltage	12V to 15V
Output Voltage	19V
Output Current	5A
Output Power	100W
Switching Frequency	52Khz

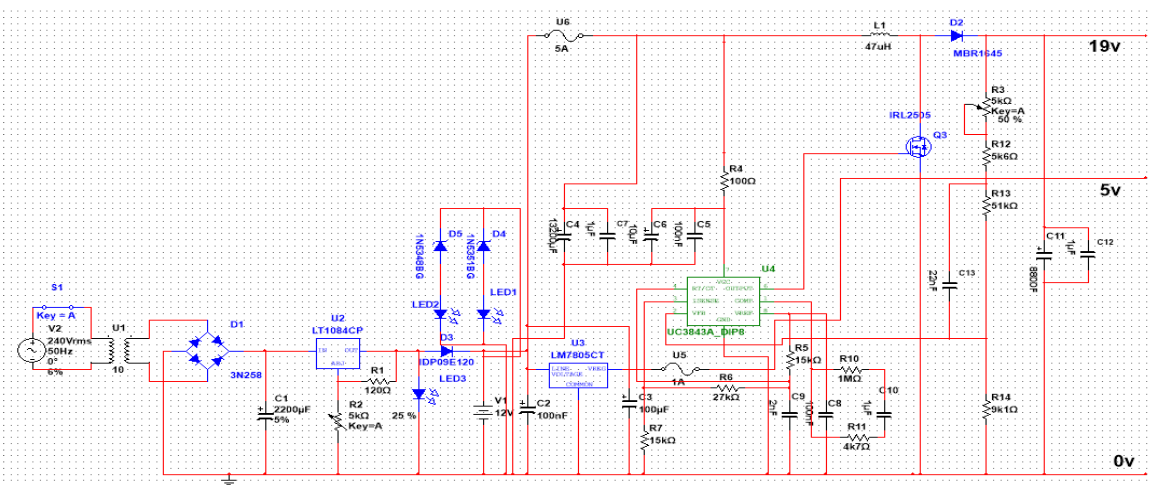

Figure 3 Circuit Diagram of Dual DC Uninterrupted Power Supply (UPS)

OPERATION OF CIRCUIT DIAGRAM

The principle of operation is a collective performance of the transformer, rectifier, charger, battery, regulator and boost converter. When power supply from the utility, is available, a 220/240V of 50Hz is feed into a 240VAC/24VAC step-down transformer. The output of the transformer which is 24VAC is rectified by a bridge rectifier to 24VDC.The output from the rectifier goes to LT1084, whose output is set by means of R2 to 14VDC.

The output of LT1084 is used to charge V1, while the power supply is ON. The feed to the input of LM7805 provides 5VDC regulated supply and also feeds the boosting stage to provide step-up voltage of 19VDC. When there is power outage, the charged battery, supplies 19VDC and 5VDC to the respective loads. The light emitting diode LED3 in the circuit, only lights-up when there is power supply and also when the battery is charging. When there is power outage, the LED3 goes off, LED2 turns on when the battery is at 10VDC which indicate that, charging is required.

LED1 turns on when the battery is 14VDC, indicating fully charge. Uc3843 is the controller IC that drives the MOSFET switch to provide the required switching of L1, while C11 and C12 filters the 19VDC output voltage of any pulsating signal.

V. RESULT AND DICUSSION

In building this project, the following procedures were taking into consideration.

- Purchase of the entire materials/components needed
- Resistance check of the components using ohmmeter, and then making the necessary connections.
- Drafting a schematic diagram on arrangement of the component
- Testing the completed system to see if it is functional.
- Finally, implementing into a finished product .

Having procured all the materials, the components were arranged on a Vero-board and proper soldering of the components was achieved.

The tools and instruments used in realizing this work include the following:

- Lead and Soldering Iron
- Lead sucker
- Copper stripping knife
- Cutter
- Razor blade
- Plier
- Digital Multimeter
- Vero board

While constructing, all components used were tested to ascertain their conformity with the required standard to demonstrate the objective of this project. Tables 2 and 3 shows the test results of the dual output (ups) on loads. Resistor value of 10ohms and 6.6ohms were used on 5VDC while 9ohms and 6ohms were used on 19VDC. The results indicate that the device is able to supply and backup loads within its specifications.

Table 2 Test on 5VDC Output

Vin(V)	Vout(V)	Rload(A)	Output Power(W)
10	4.93	0.50	2.47
11	4.94	0.75	3.71
12	4.90	0.50	2.45
13	4.88	0.50	2.44
14	4.92	0.75	3.69

Table 3 Test on 19VDC Output

Vin(V)	Vout(V)	Rload(A)	Output Power(W)
10.80	18.58	2.10	39.02

10.50	18.51	3.20	59.23
11.00	18.57	2.10	38.10
11.15	18.50	3.30	61.05
12.00	18.51	3.10	57.38
12.80	18.58	2.20	40.88
13.50	18.52	3.10	57.41
13.00	18.56	2.30	42.69
14.00	18.55	2.20	40.81
14.40	18.50	3.10	57.35

VI. CONCLUSION AND RECOMMENDATION

CONCLUSION

The design and fabrication of a dual dc UPS system to supply DC power directly to laptops and cell phone devices was successfully completed.

The battery charger was able to charge the battery, with an indicator to show its charging state. Multistage charging was implemented, by using LT1084, which uses differential voltage to control the charging of the battery, and places it on float charge when the battery is fully charged.

In this design, the mains power was given priority over the battery power; therefore, so long as the mains are available, the load would be connected to them. The load would only be connected to the battery when the mains are unavailable.

RECOMMENDATION.

It is recommended for future studies to incorporate a universal outlet for the 19VDC laptop, in order to serve more than one brand of laptop. The design outlet in this work was limited to HP brand and smart TVs with same specifications. The technology can be embedded into sensitive systems to serve as backup to provide a save turn OFF in the event of an outage.

REFERENCES

Åkerlund J., and Gennäs C.B, (2007). ‘comparison of the ac ups and the dc up solutions for critical loads’, Labs AB, Sweden

Brigitte Hauke, (2014), Basic Calculation of a Boost Converter's Power Stage’ Texas Instruments Incorporated

George Arthur Navarro (2016), ups systems and methods using mode-dependent grounding

Joseph Shu (2003), uninterrupted power supply (ups) with build-in USB hub

Krishnan, R. and Srinivasan, S., (2004), “Topologies for Uninterruptible Power Supplies”.

Paulakonis et al (1993), uninterruptible power supplyhaving improved battery charger

Steven Mark Groff and Trung le (2010), dc ups with auto-ranging backup voltage capacity

Simonelli et al (2009), system for and methods of controlling operation of a UPS